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TDR-594(1101)TN-1

Buffeting Data Obtained on Mercury/Atlas MA-2 and MA-3

21 AUGUST 1961

Prepared by G. YOUNG and T. SHIOKARI

Prepared for DEPUTY COMMANDER AEROSPACE SYSTEMS
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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ABSTRACT

Two Mercury/Atlas vehicles, MA-2 and MA-3, were instrumented in order to evaluate vehicle structural integrity under flight conditions. The instrumentation system was oriented toward obtaining dynamic rather than static type data since no buffeting data have been obtained on the Mercury configuration. Flight data were obtained through the complete sonic region on MA-2; however, data only up to low transonic region were obtained on MA-3. Structural response data on the adapter and upper LOX tank were obtained. Due to the improper choice of the transducers and ranges, no quantitative data were obtained for adapter vibration and pressure. In general, the data indicated the buffeting loads on the LOX tanks were relatively low on the successful MA-2 and on the abbreviated MA-3 flight.

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I. INTRODUCTION

On 29 July 1960 the second Mercury/Atlas, MA-1, failed near maximum dynamic pressure. Limited data were available for attempting to explain the failure, which was of a catastrophic nature. During the following months, a number of possible causes and fixes were investigated. One of these investigations (Reference 1) covered dynamic loads due to buffeting in the unpressurized adapter area (Figure 1). A rigid wind tunnel model was used and aerodynamic pressure fluctuations were measured. Although there were fluctuations through the entire spectrum, the conclusions reached were that, assuming unity correlation and no possibility of deflection-pressure feedback, buffeting loads would not exceed 25 per cent of allowable loads. The capsule-adapter forward LOX tank combination was noise tested to a level of 152 db by NASA and no large strains were detected. Panel flutter and dynamic buckling were not investigated. For MA-2, the ring stiffeners on the adapter were stiffened by a factor of 10 and a restraining band was added at the forward portion of the LOX tank. For MA-3, the upper LOX tank skin thickness was increased by a factor of 3. A special telemetry package was added to MA-2 and MA-3 in order to obtain aerodynamic noise input and structural response.

II. INSTRUMENTATION

A. MA-2

The transducers measured strain, pressure, acceleration, and vibration. The types and locations are shown in Figure 2 and are listed in Table 1 In general, the frequency response characteristics of the transducers were good, but due to telemetry limitations, only a few were usable for high frequency data.

The strain gauges, due to doubt as to temperature corrections, could give only approximate static loads However, the dynamic strains are considered good. The pressure pickups were CEC 4-312, which are subject to large errors at high g levels. The vibration pickups were Gulton A-395, which are piezo electric types. One Statham accelerometer was used. Other pickups, namely displacements and breakwires, were used to detect failures.

B. MA-3

Due to the poor quality of the 4-312 pressure gauges under vibration, it was decided to replace them on MA-3. The 4-325 was recommended as being much less sensitive to vibration. Because of timing and availability, an attempt was made to change only one ΔP gauge for the highest frequency channel. During installation, the gauge was damaged and a replacement was not available. A recent test, however, has shown the 4-325 to be only slightly better than the 4-312.

Various engineers estimated the vibration level on MA-2 to be in the range of ± 65 to ± 200 g's whereas the channel range was set for ± 25 g's. For MA-3, the range was set to cover ± 311 g's. Figure 3 gives the MA-3 instrumentation.

III. DATA REDUCTION

The data reduction technique is to review in sequence: (a) the raw data at various times of flight; (b) the RMS's versus time of flight; and (c) analyze by power spectrum at various selected times of flight. For the PSD's presented in this report, times at $M = 1.0$ and at maximum dynamic pressure were selected for MA-2.

Figure 4 shows typical vibration signals. Figures 5 through 7 give RMS versus time for several high frequency channels. Figures 8 through 12 give PSD plots for the selected times of flight. Most of the signals were extremely clean so that channel low pass filters of two and three times standard frequency could be used without introducing unacceptable noise levels or signal distortion. Several discussions of the data have taken place between NASA/MAC/GD-A/Aerospace. The correlation between groups is good.

IV. DISCUSSION

Data were obtained for the MA-2 flight, which was successful; however, MA-3 was destroyed by the Range Safety Officer prior to the transonic regime because the missile was off course. Since buffeting is primarily a transonic phenomenon and MA-3 did not exceed $M = 0.7$, extrapolation can give only an approximate answer in attempting to correlate MA-2 and MA-3 data.

No dynamic buckling or panel flutter occurred on MA-2. Since no real changes occurred from MA-1 to MA-2 from the standpoint of panel flutter, it is believed that none existed on MA-1.

It can be noted from comparing the plots of Figure 5 that the MA-3 vibration level was several times as great as MA-2. Remembering that the adapter rings of MA-1 were only 10 per cent as stiff as the rings of MA-2 and MA-3, it is possible that mere resonance in the adapter area could have been the cause of failure in MA-1.

The pressure data from both MA-2 and MA-3 is unusable since the error signal due to the estimated vibration level is of the same order of magnitude as the total signal obtained, and the error signal is at the vibration frequency. The aerodynamic noise spectrum should be near white if it is assumed that no vibration-pressure feedback exists. Moreover, had this not been the case, no aerodynamic pressure data would have been obtained since the static orifices of the diaphragms were vented to the interior, not the exterior, of the adapter. Thus, the interior noise is reinforcing or cancelling the exterior aerodynamic fluctuations.

The adapter vibration data gives little quantitative data on transonic vibration levels since the transonic regime begins at about t = 40 seconds, whereas the MA-2 signal was out of band after t = 30 seconds and MA-3 was destroyed at t = 40 seconds. One item obtained of great interest was the excitation of discrete frequency higher order modes, probably due to the pressure pattern excited by the three Marman clamps just ahead of the adapter. Figures 8, 9, 11, and 12 illustrate this phenomenon. The reason for the difference in discrete frequencies between the various plots is possibly due to the difference in locations of the transducers around and along the adapter.

V. CONCLUSIONS

The adapter and upper LOX tank did vibrate due to aerodynamic buffeting. The amplitude was not sufficient to cause concern for MA-2. The MA-3 adapter vibration was greater than MA-2 prior to the transonic regime. This was probably due to relative difference in "noisiness" between the two vehicles.

Buffeting loads on the upper LOX tank were of the order of 2 to 3 per cent of limit loads for MA-2. Buffeting loads on MA-3 were not obtained since the flight was terminated prior to reaching the transonic regime.

Flight buffeting pressures have not been obtained from these series of Mercury/Atlas flights. The pressure data obtained was actually an error signal generated by the vibration environment. The transducer's vibrational sensitivity would give apparent pressures from the estimated vibration magnitude of the order of the measured pressure. Furthermore, the pressure pickups were differential type gauges which would not give the fluctuating aerodynamic pressures.

VI. RECOMMENDATIONS

An attempt has been made to obtain dynamic and static type structural response and aerodynamic excitation in the adapter area on two Mercury/Atlas flights. Data acquisition was relatively good. However, the choice and location of the end instruments and calibrations were unsatisfactory. This flight series was one of the first attempts for space boosters to acquire this type of data. Some qualitative data has been obtained. Due to the lack of quantitative data on buffeting throughout the industry, further attempts should be made to obtain this data.

It is therefore recommended that a compact standard telepack be made available for telemetering the above mentioned data. These data will require high frequency response channels. Also a cursory state-of-the-art evaluation of end instruments such as vibration compensated pressure pickups and strain gauges under a varying temperature environment should be made. In addition, the telemetry systems should have capabilities of performing inflight calibrations. In general, all of these units are available, but proper evaluations have not been performed and they are yet to be proved for flight conditions.

REFERENCES

1. Goldberg, A.P., and R. H. Adams, "Mercury-Atlas Buffeting Loads at Transonic and Low Supersonic Speeds", 28 November 1960. STL/TR-60-0000-AS431.

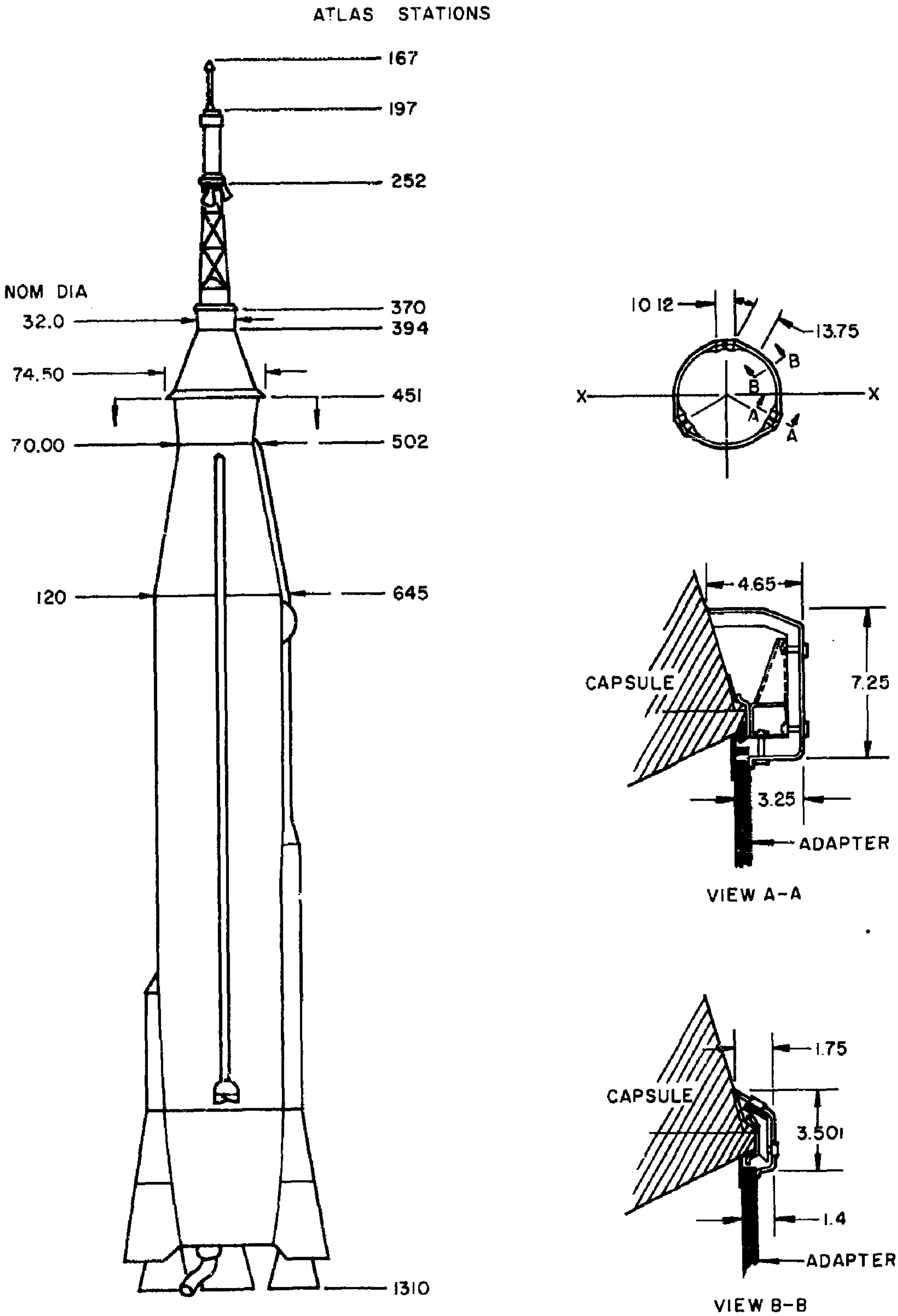


Figure 1. Mercury/Atlas Configuration.

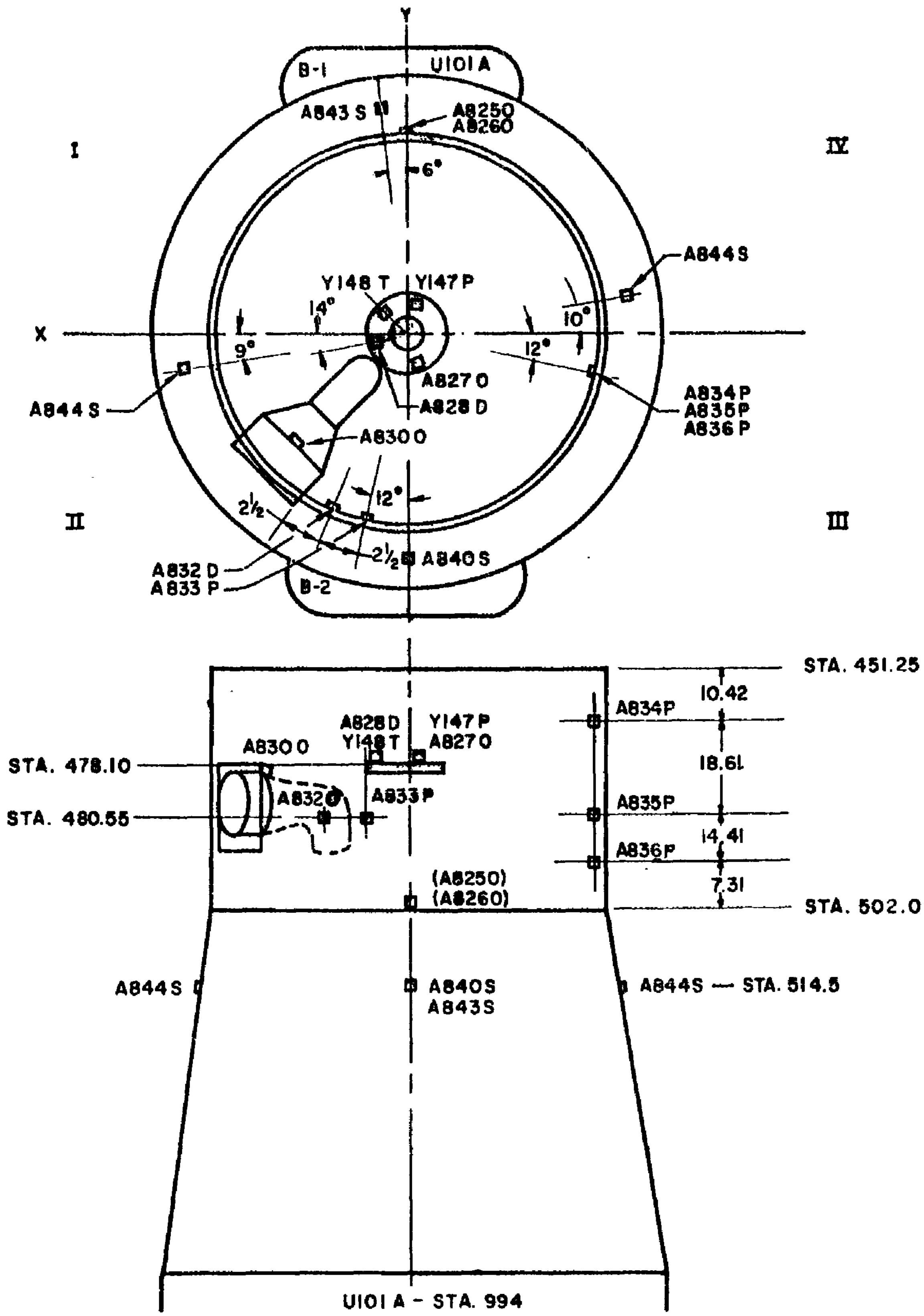


Figure 2. Special Instrumentation Transducer Location on MA-2.

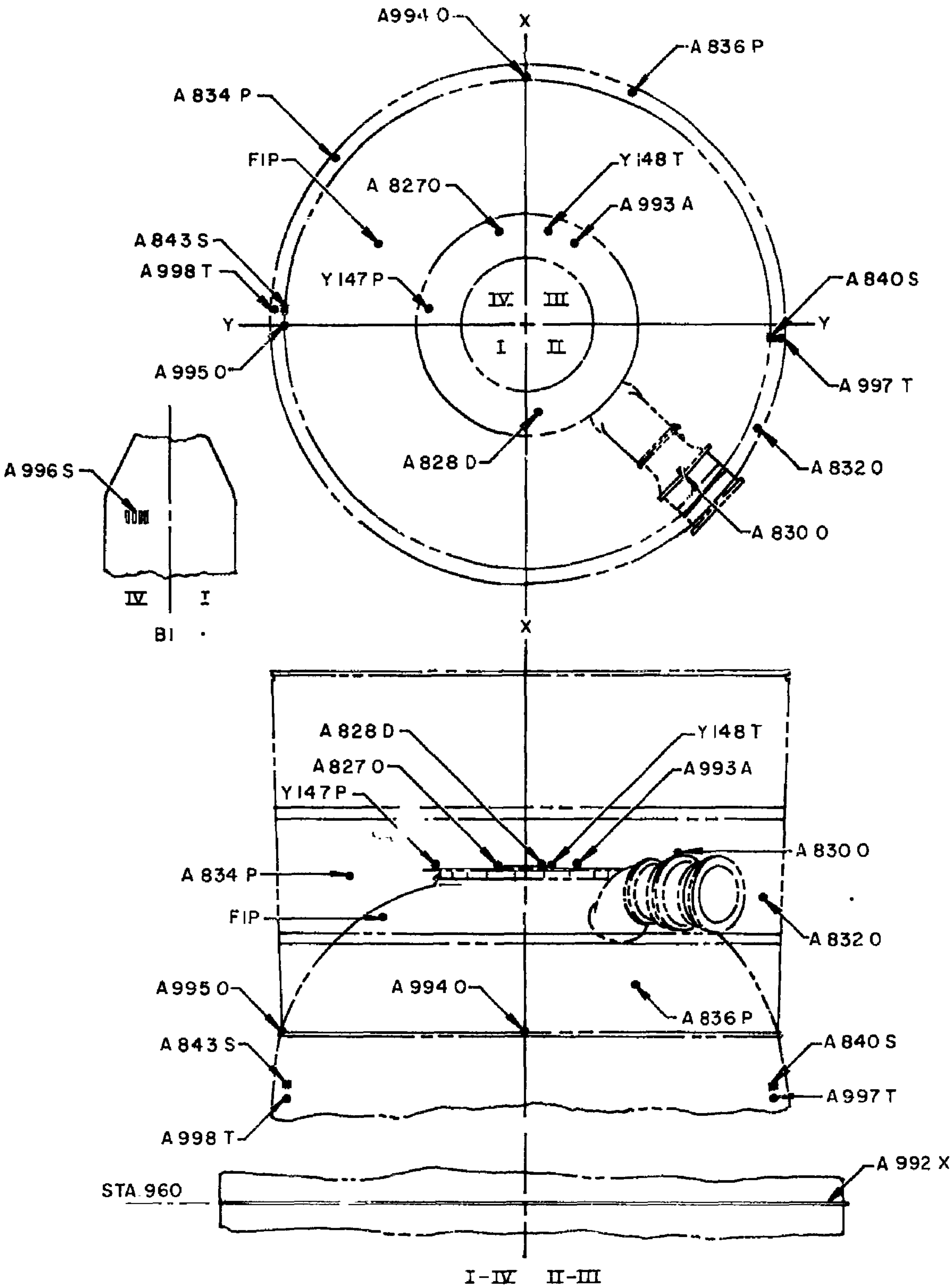
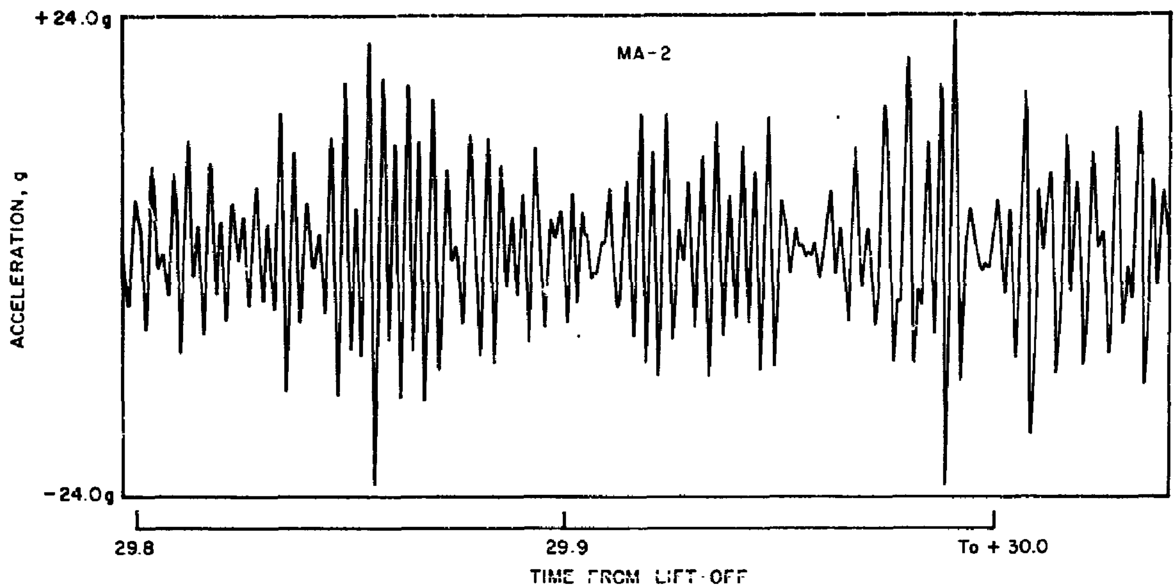
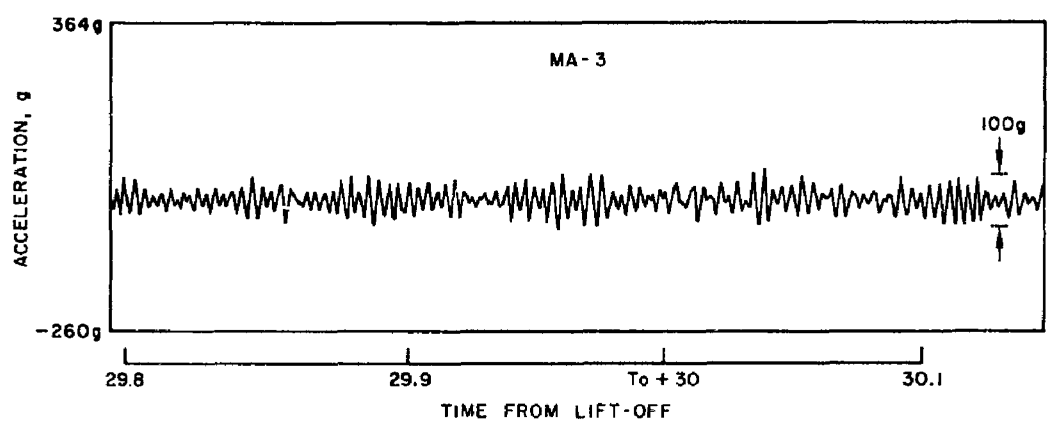


Figure 3. Adapter Area Instrumentation on MA-3.





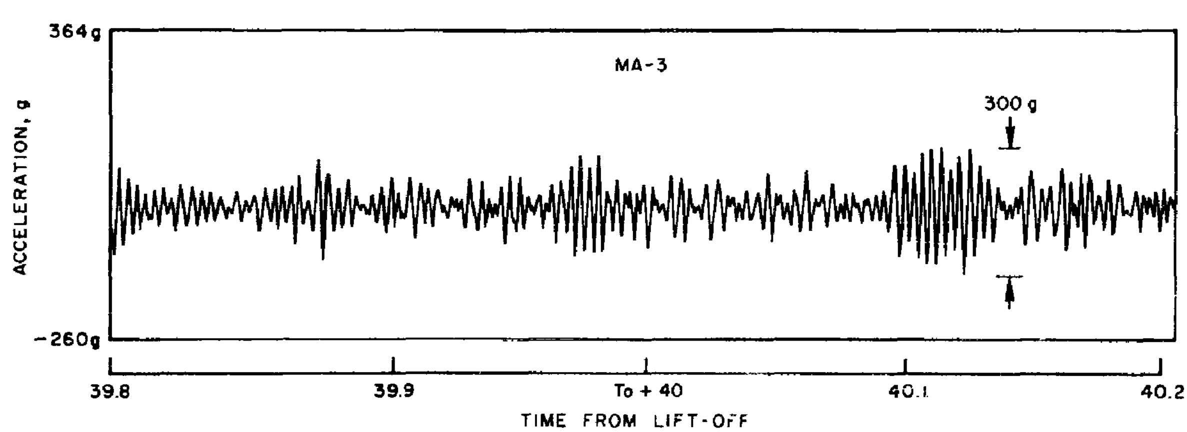
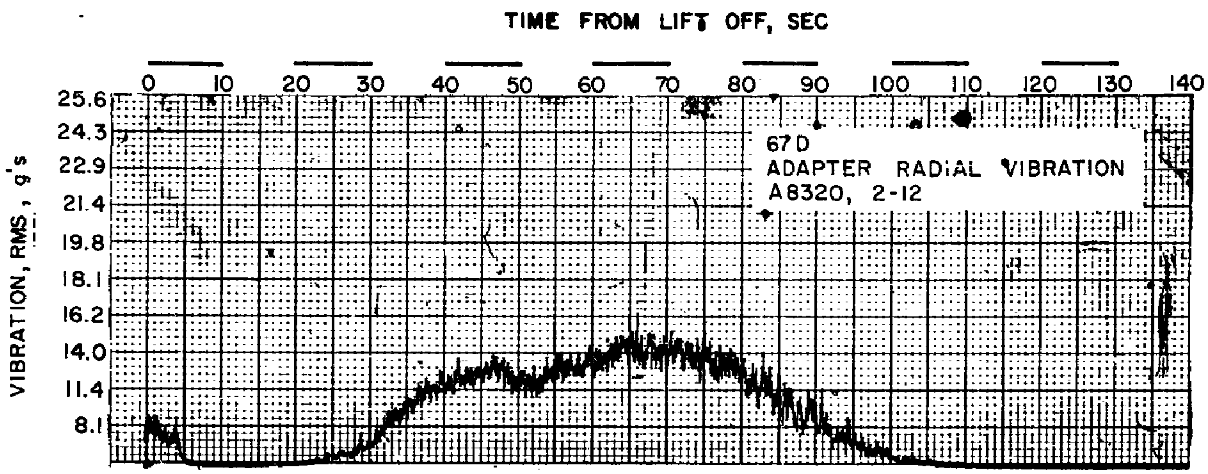


Figure 4. Adapter Vibration (A8320).



Note: Signal chopped after t = 30 seconds.

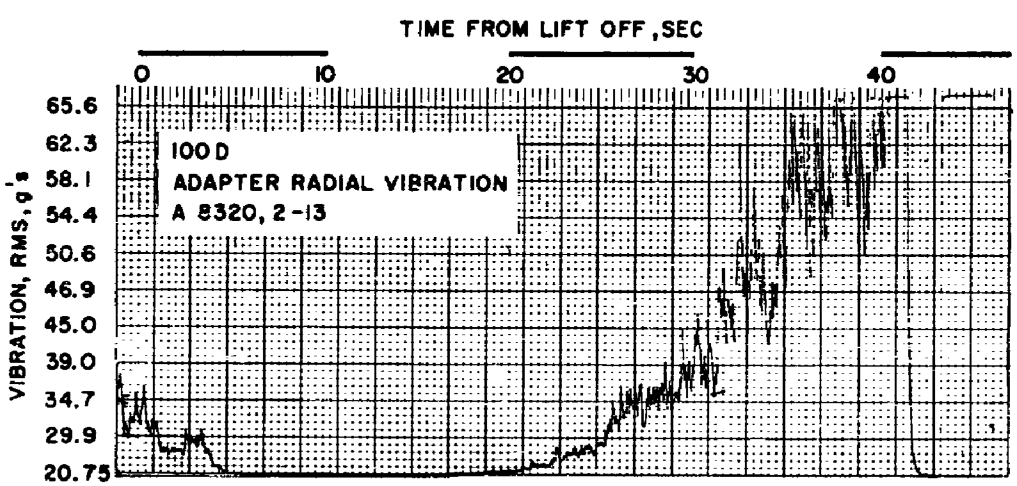
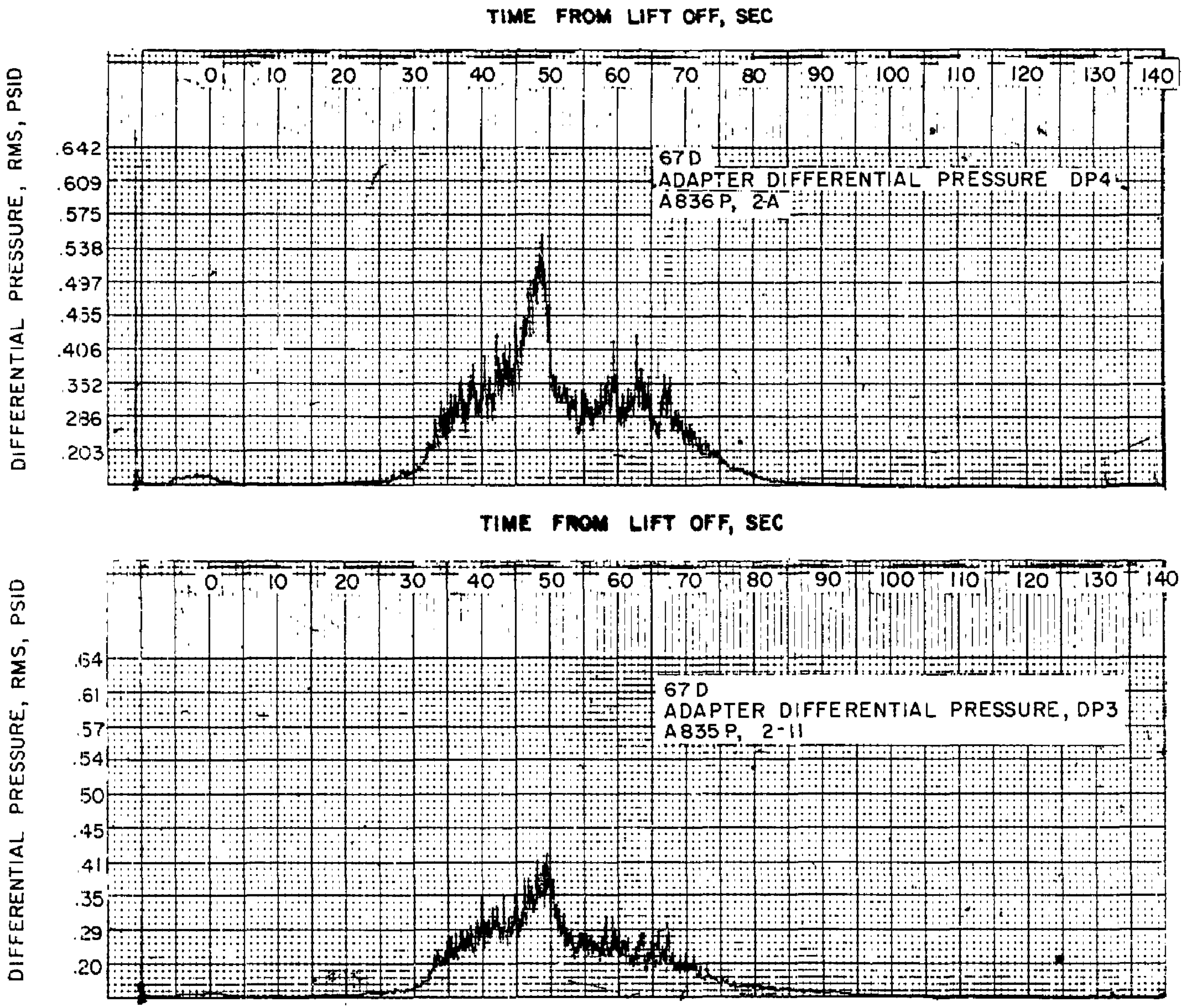


Figure 5. ᴾMS ; of Adapter Radial Vibration.



Note: This data contains a vibration generated error signal of the same order of magnitude as the total signal.

Figure 6. RMS Plots of Adapter Differential Pressure.

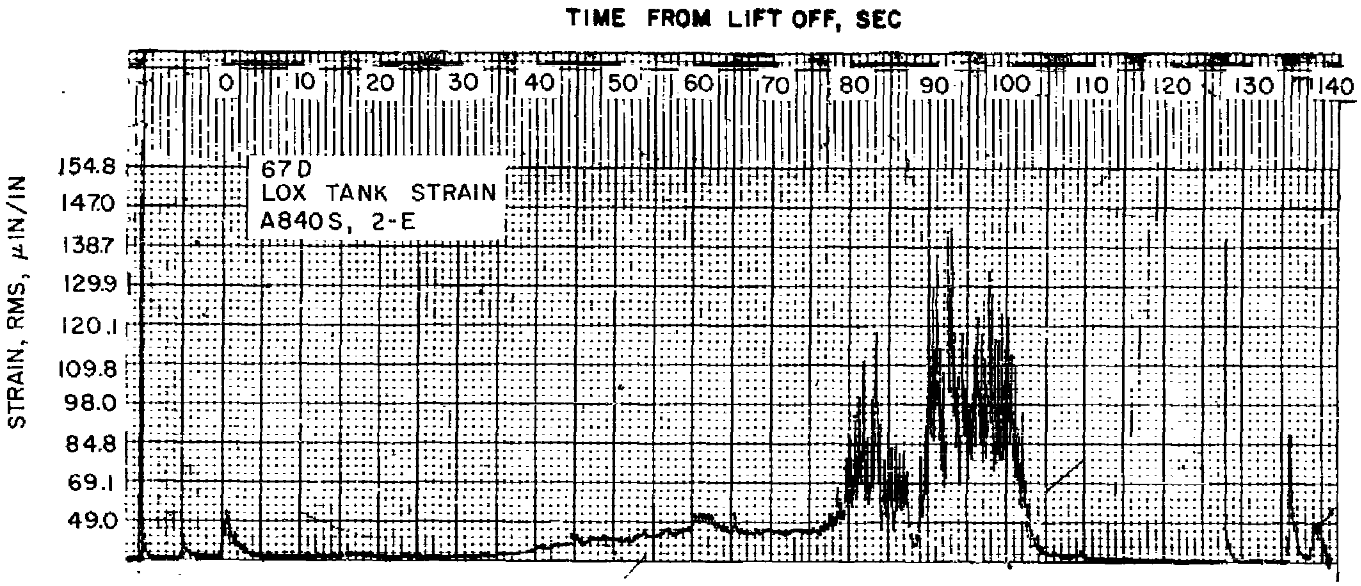


Figure 7. RMS Plot of LOX Tank Strains.

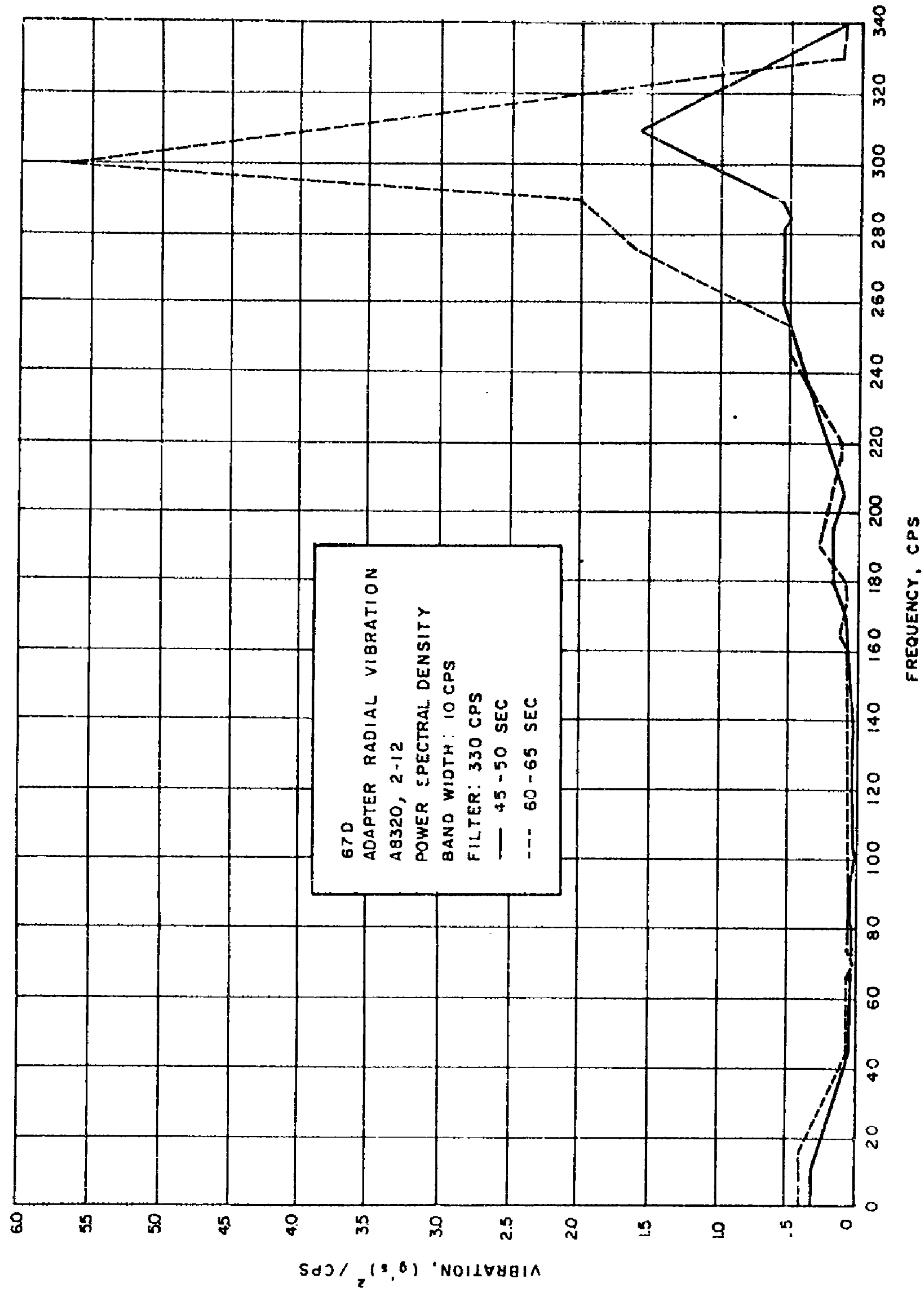


Figure 8. Adapter Radial Vibration Power Spectra.

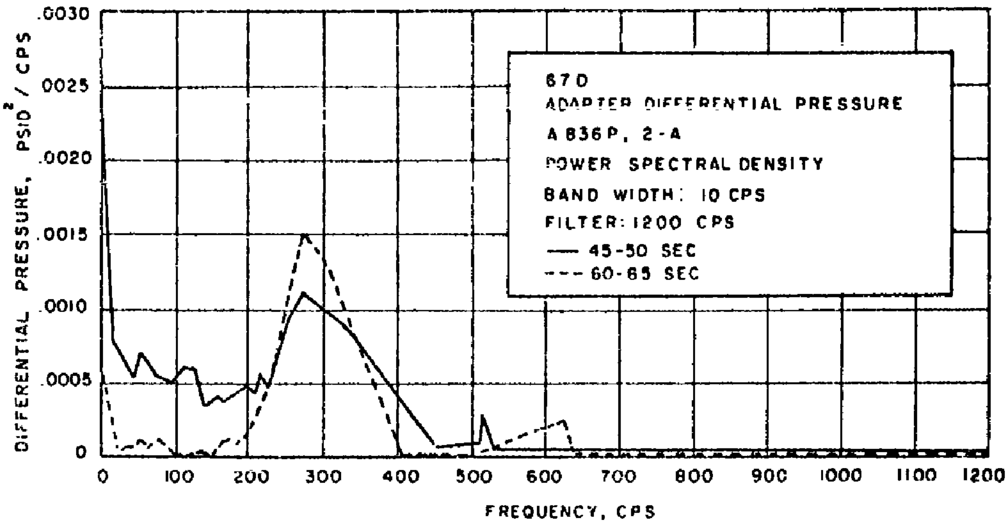


Figure 9. Differential Pressure Power Spectra.

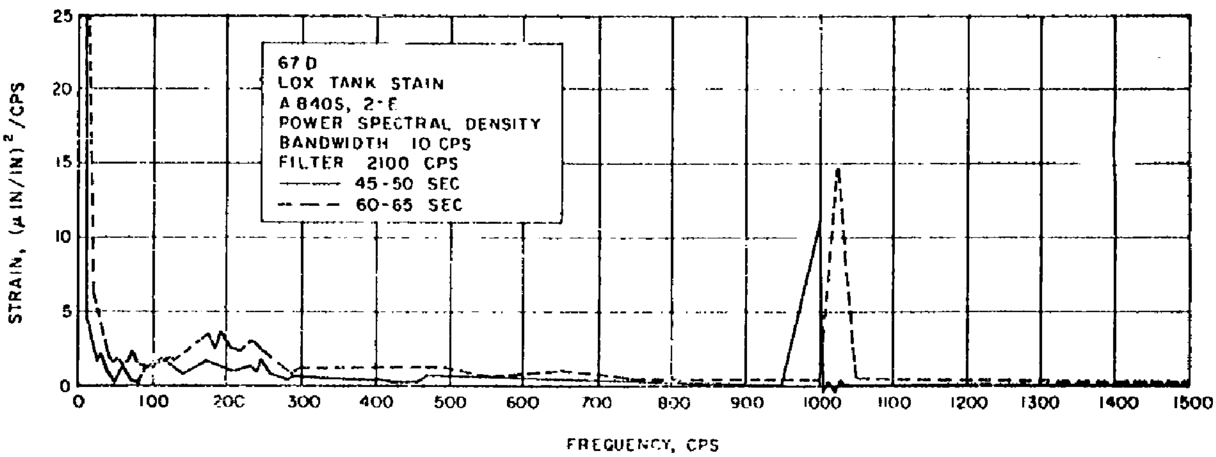


Figure 10. LOX Tank Strain Power Spectra.

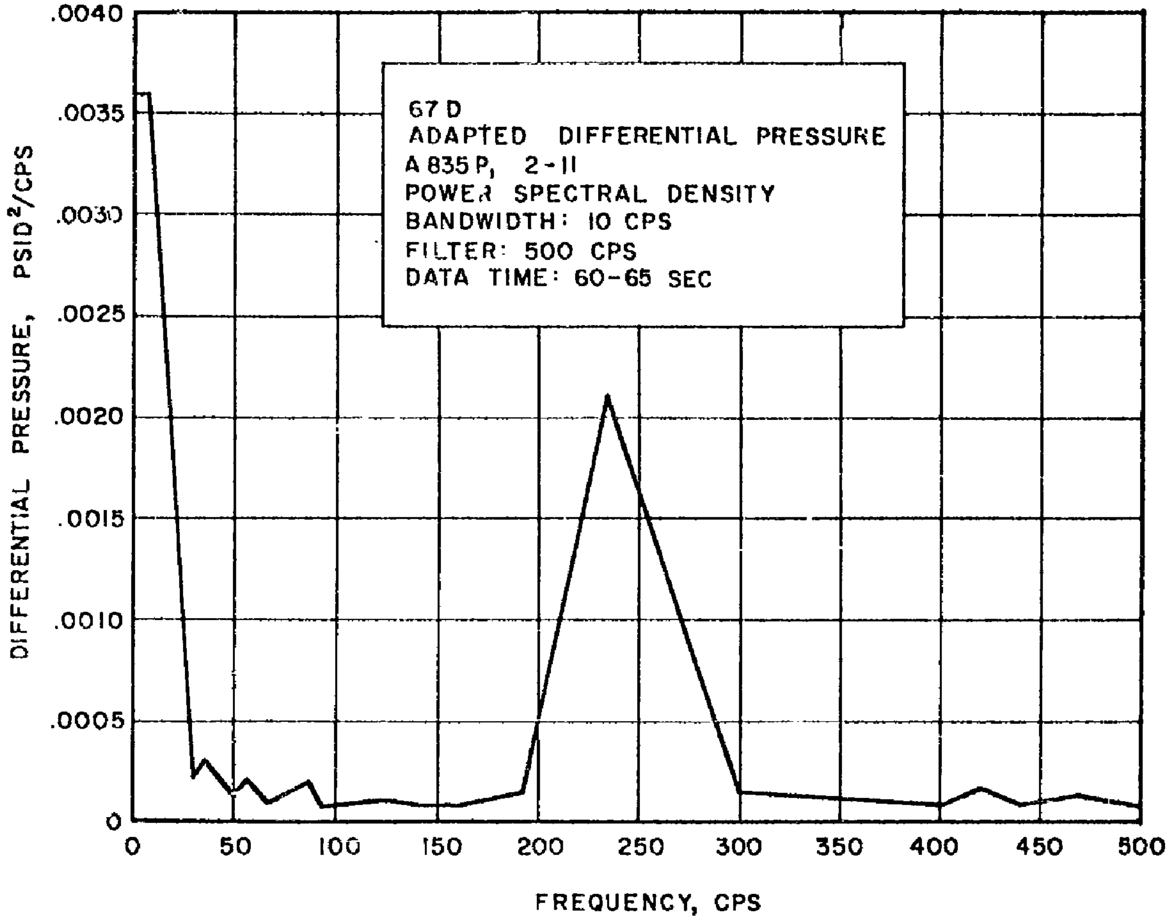


Figure 11. Adapter Differential Pressure Power Spectra.

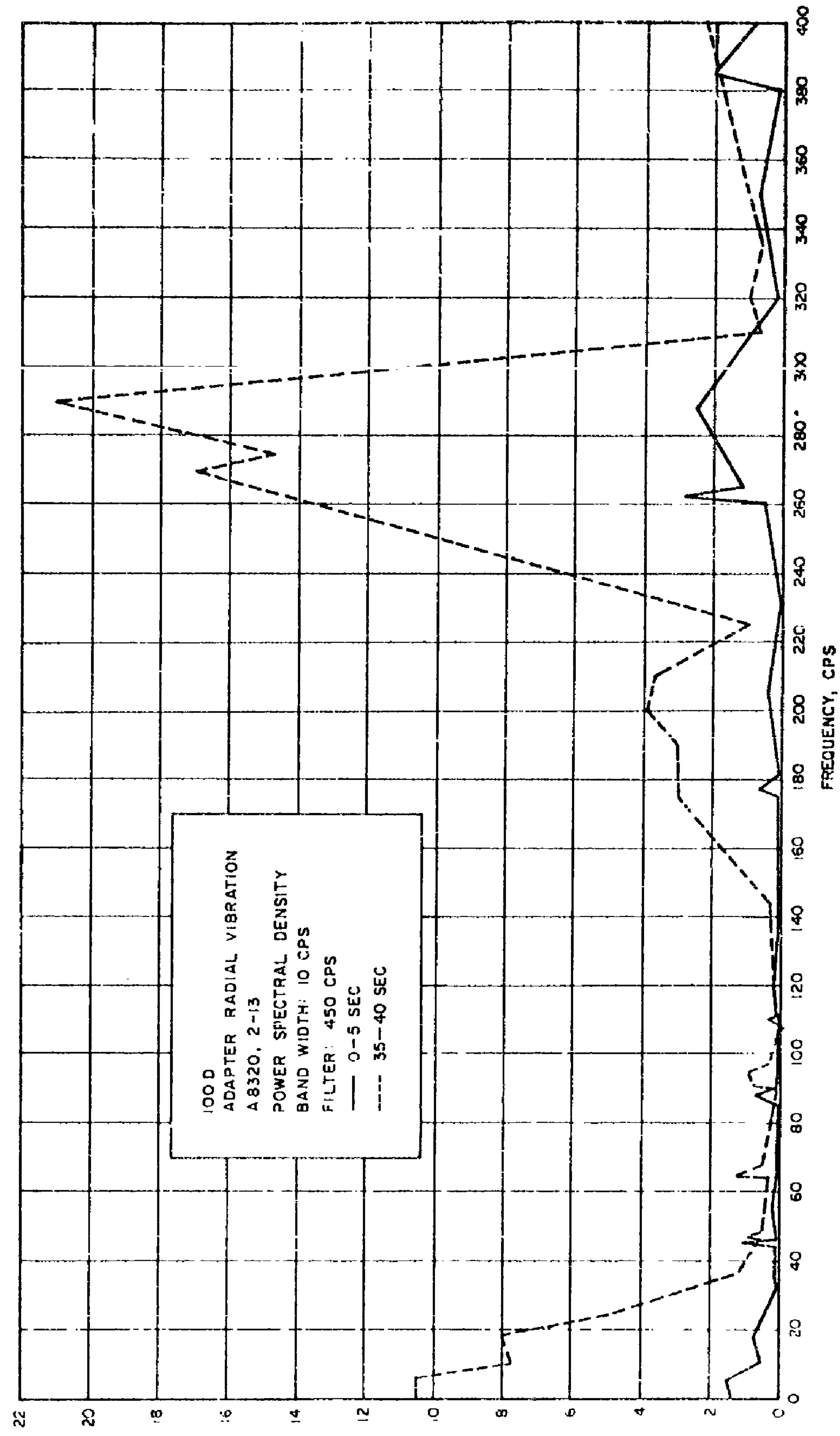


Figure 12. Adapter Radial Vibration Power Spectra

Table 1. Instrumentation Description.

Adapter

Pressure

A833P	Differential Near LOX Boiloff
A834P	Differential
A835P	Differential
A836P	Differential
Y147P	Ambient Pressure in Adapter Area

Vibration

A8250	Adapter Base Longitudinal
A8260	Adapter Base Tangential
A8320	Adapter Radial Near LOX Boiloff
A9940	Adapter Base Radial Yaw
A9950	Adapter Base Radial Pitch

Booster

Strain Gauges

A840S	LOX Tank Pitch Strain
A843S	LOX Tank Pitch Strain
A844S	LOX Tank Yaw Bending Strain
A996S	Lower LOX Tank Strain

General

FIP	LOX Tank Helium Pressure
A8300	Boiloff Valve Tangential Vibration
A8270	Manhole Cover Longitudinal Accelerometer
A828D	Manhole Cover/Retro Package Displacement
A997T	LOX Tank Temperature
A998T	LOX Tank Temperature
A993A	Pitch Accelerometer on LOX Dome
A992X	Breakwire

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